APPLICATION

FOR

UNITED STATES LETTERS PATENT

Be it known that I, Michael E. Gvili, residing at 18 Loblolly Lane, Wayland, Massachusetts 01778; Stanisslav Mezhebovsky, residing at 15 Willis Lake Drive, Sudbury, Massachusetts 01776; Martin James Northern, residing at 8914 Woodrow Road, Wolfforth, Texas 79382; and Robert Lynn Locus, residing at 5601 CR 6170, Lubbock, Texas 79415, and each being a citizen of the United States of America, have invented a certain new and useful

APPARATUS AND METHOD FOR CONTROLLING
THE AMOUNT OF TRASH IN LINT

of which the following is a specification:

Applicant: Michael E. Gvilli et al.
For: Apparatus and Method for Controlling the Amount of Trash in Lint

ABSTRACT

An apparatus and algorithm for controlling the operation of a lint cleaner in a cotton gin having motorized grid bars, in which any one of the grid bars can be positioned in an engaged or disengaged position. When the grid bar is in the engaged position it functions as a lint cleaning instrument on a lint cleaning machine. When it is in the disengaged position it does not participate in the active cleaning process.

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For: Apparatus and Method for Controlling the Amount of Trash in Lint

FIELD OF THE INVENTION

This invention relates to the lint cleaning process and machinery used in cotton processing facilities such as cotton gins. The invention provides an apparatus and methods for controlling the amount of cleaning performed during the lint cleaning process, thus optimizing the cotton producer's income by reducing waste and damage to the lint.

BACKGROUND OF THE INVENTION

Lint cleaning machines, used in cotton processing facilities, employ stationary grid bars to remove trash, leaves and other particles from the lint during the cleaning process, as described in W.S. Anthony and William D. Mayfield; Cotton Ginners Hand Book United States Department of Agriculture; Agricultural Research Service Agricultural Handbook Number 503; Copyright December 1994 . The lint cleaner uses a bank of circular saws to propel a thin preconditioned layer of lint through the lint cleaning machine. The lint fibers, which may contain leaf fragments, seed fragments, sticks and other particles designated herein as trash, are fed onto the fine teeth of the saws, which are rotating at the speed of a few hundred revolutions per minute. During one half of a revolution around the cleaner, the lint fibers pass by a set of five or more closely positioned bars with sharp edges, referred to as grid bars. These grid bars are positioned perpendicular to the rotation of the saws, with the edges very close to the saws. As the lint passes by the grid bars, most of the trash in the lint is dislodged by the grid bars and sucked into a trash air pipe, which then feeds the trash to a trash heap outside the gin house. The saws continue pulling the lint through most of the revolution. The lint is then separated from the saws by a cylindrical brush and from there is conveyed to a bale press for packing. The bale

press packages the lint into 500 pounds bundles of pressed lint called bales.

The grid bars are long metal bars with a sharp leading edge used to remove the trash from the lint upon contact. It has been demonstrated that during the cleaning process the grid bars also remove some usable lint from the rotating saws, causing a loss of lint to the producer. It has been further determined that the amount of trash and lint removed during the cleaning process is dependent on many factors. These include the mechanical positioning of the grid bars, the sharpness of the cleaning edge, the condition of the lint, the lint properties, the mechanical properties of the saws, their speed and other factors. It has been demonstrated that the loss of useable lint can decreased by reducing the amount of cleaning the machine performs. It has also been demonstrated that reducing the amount of cleaning results in longer fibers and reduction in short fibers. Reduction in the lint cleaning thus results in the improvement of the quality of the cotton. In many situations, the cotton producer is interested in minimizing the loss of lint during the cleaning process, even if it will result in higher trash content. Existing lint cleaners do not provide a method to vary the amount of cleaning the machine performs.

US Patent 5,909,786 by Anthony, describes an apparatus to reduce fiber waste by lint cleaners. Anthony's invention describes a method where the space between the grid bars is closed by shroud members, while the grid bars themselves remain stationary during the cleaning process. The disadvantage of Anthony's invention is that it does not remove sheet metal edges from contacting the lint, thus continuing to cause damage to the fibers. Also, Anthony's invention is complex to build and operate.

Some trash particles are not removed by the lint cleaner. They remain with the lint through out the remainder of the cleaning process. The amount of trash remaining in the lint will

be measured as a leaf count. The leaf count is one of the parameters used to determine the quality of the lint.

SUMMARY OF THE INVENTION

An apparatus and algorithm for controlling the operation of a lint cleaner in a cotton gin having motorized grid bars, in which any one of the grid bars can be positioned in an engaged or disengaged position. When the grid bar is in the engaged position it functions as a lint cleaning instrument on a lint cleaning machine. When it is in the disengaged position it does not participate in the active cleaning process. The grid bars can be engaged or disengaged in the cleaning operation by electrical, pneumatic or hydraulic actuators, which are activated by the system processor. The operator interface device, which contains at least a trash level indicator and a data entry device, allows the operator to enter the desired cotton gin output trash level. An imaging device, such as a digital camera or a scanner, measures the amount of trash present in the lint before cleaning plus another imaging device, like a digital camera or a scanner, measures the amount of trash remaining in the lint at the cotton gin output after the lint cleaning process. The signal received from the imaging devices is analyzed and the trash content is determined. The invention algorithm determines which grid bars should be engaged in the cleaning process to obtain the operator's desired output trash content. An alternate algorithm can be used to calculate the most cost effective cleaning process based on commodity pricing, trash discount or quantity of lint wasted.

This invention further comprises an automatic control for lint cleaning machines where the cleanliness of the lint is monitored by an imaging device such as a camera or scanner, and an assembly of motorized bars. The motorized grid bars are dynamically configured by the invention's algorithm to produce the desired level of cleaning.

The inventive system is represented in FIG. 1, but is not limited to the components of FIG. 1. It consists of an imaging device which can estimate the amount of trash existing in the lint before it enters the lint cleaner, and a second imaging device at the exit point of the lint cleaner or at the final station when the bat is packaged into a bale of cotton. An estimate of the amount of trash in the cotton during process is calculated continuously; several times for each bale. The results are then averaged to obtain a moment by moment condition of cleanliness before and after the cotton is cleaned. This occurs in a timely fashion so the lint cleaner process algorithm can be performed. This invention also includes movable grid bars, typically either movable by hand, or by the use of motors, which may be manually or automatically controlled to engage and disengage one or more grid bars. These grid bars are equipped with electrical motors, or pneumatic or hydraulic actuators, or other remotely controlled actuators, referred to here as grid bar actuators. The actuators enable the invention's lint cleaner controller to position the grid bars against the rotating battery of saws, referred to herein as the engaged position, or to separate them so they do not take part in the cleaning process, referred here as the disengaged position. While the grid bar is in the engaged position it is functioning as a trash-removing surface which removes trash from the cotton being cleaned. Any one of the grid bars can be independently repositioned by the actuators, at any moment during the cleaning process. A grid bar can be moved to the disengaged position where the surface of its cleaning edge is no longer in contact with the lint or the trash. In this position, the grid bar is not being used as cleaning device, and in that position it no longer cause any loss of lint or damage to it.

The grid bars may also be equipped with a lint-retaining member such as retention bars or retention brushes or both, as shown in FIGS. 6 and 7. Both the retention bar and the retention brush keep the lint in contact with the saws when the grid bar is in the disengaged position. The

retention bar or brush prevents the possibility of dislodging the lint from the saw by the fast flowing air. The dislodging of lint from the saws is due to the centrifugal forces applied by the spinning of the saws.

This invention also includes a user interface terminal where the operator has the ability to set the desired output trash level, and also to adjust other system parameters. They can also view the condition of the cleaning process in regards to the position of each of the grid bars. The operator can reposition the grid bars in a manual mode by commanding the processor to engage or disengage any selected grid bar at any time.

This invention includes a processor, which executes a sequence of commands, embedded in its memory, constituting the algorithm of the invention. The processor receives inputs from the optical sensing devices, it also receive instructions and or set point from the operator. It uses these inputs to determine if it is necessary for one or more of the grid bars to be repositioned to the engaged or disengaged position. If there is a need the processor can use these inputs to tell which of the grid bars need repositioning.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram of one embodiment of the invention, having a lint cleaner with movable grid bars.

FIG. 2 is a system diagram of one embodiment of a lint cleaning, control and monitoring system of the invention.

FIG. 3 is a diagram of one embodiment of motorized grid bars mounted on a lint cleaner according to the invention.

FIG. 4 is a diagram of an alternative motorized grid bar using worm gear.

FIG. 4a is a diagram of another alternative motorized grid bar using a solenoid type of

actuator for the grid bars of the invention.

FIG. 5 is a diagram of another alternative pneumatic or hydraulic type actuators for the grid bars of the invention.

FIG. 6 is a diagram of a grid bar of the invention, which is moved along an arched and linear positioning groove.

FIG. 6a is a diagram of an inventive grid bar, with a solid lint retention member.

FIG. 7 is a diagram of another inventive grid bar, with a lint retaining brush.

FIG. 8 is a diagram of a closed control loop for an embodiment of the invention.

FIG. 9 is a block diagram of another control scheme according to the invention.

FIG. 10 is a schematic diagram of a three-way valve used to bypass a second lint cleaner, illustrating another feature of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The invention of lint cleaning machine in a cotton processing facility such as cotton gin, is illustrated in FIG. 1. The lint cleaner is comprised of a battery of saws 1 containing multiple, round, narrow saws of the typical diameter ranging from 16 to 24 inches. All of the saws are spinning around the same axis 2 and driven by a single motor or mechanical drive or gear 3 through the shaft or belt 4. The motor or gear 3 is mounted on a stationary frame 5 of the lint cleaner, which also supports the housing and other components of the lint cleaner 6. On the frame 5 are several mounted grid bars 7 and 8 as shown in FIG. 1. The invention applies to the use of one or more grid bars in a lint cleaning machine. Each of the grid bars is mounted on a pivoting shaft 9 and 10. Electric motors 11, 12, 13 and 14, such as step motor with or without a gear, rotary solenoids or other actuators are coupled to the shafts, to controllably rotate the shafts. These grid bars are mounted respectively on ribs 15 of the frame 5 and are coupled to the

shafts of the corresponding grid bars as shown. This allows a fine control of the rotation and angle of the grid bars during the operation of the lint cleaning process. The motors are fed electrical power and electrical signals, via power and signal cables 17. The motors 11, 12, 13 and 14 can rotate the respective grid bars to the desired angle in relation to the spinning saws 1.

As part of this invention shown in FIG. 2, a layer of lint 16 is fed into a lint cleaning machine 5. An input imaging device 70 is capturing images of the incoming lint and transferring them to the signal processor 69 for trash level evaluation. The lint cleaning machine 5 consists of at least a battery of rotating saws 1 and a multiplicity of the inventive motorized grid bars 7 with actuators 11 and 12, and the motorized grid bar 8 with actuators 13 and 14. Trash 27 and residual lint fibers 28 are removed from the lint 16 by the grid bars 7 and 8. The clean lint is fed from the lint cleaning machine into a condenser and from there to a lint slide where the output imaging device 73 is taking images of the lint after the lint cleaning process and transferring the images to the output image processor 69A. The output image processor evaluates the images and calculates the amount of leaves and trash 27 remaining with the lint. That information is fed into the system processor for final determination of the grid bars deployment. The system processor uses the inventive algorithm to determine what shall be the grid bar deployment at that moment based on the leaf and trash contents at the input and the output of the cleaners, and the desired output leaf count as fed to it by the operator using the operator terminal 66. The deployment is executed by the motorized grid bar driver 18 which sends the needed electrical signal to the grid bar actuators.

As shown in FIG. 3, when grid bar 7 is rotated to a reference angle 24, it will be in a position where its sharp cleaning edge 25 is near the edge of the teeth 26 of the spinning saw 1. This distance typically ranges from 30 to 60 thousandths of an inch, thus it will be participating

in the cleaning process. This position is defined as the engaged position when the grid bar is engaged in the cleaning process. Trash particles 27 which are attached to the lint at the beginning of the process, may be removed and separated from the lint as it hits the cleaning edge of the grid bar 27. During the operation, some usable lint 28 will also be separated from the lint 16 which is spun by the saws 1. Not all the trash particles are removed by the first grid bar 7. Some trash particles will be removed by subsequent grid bars which are in the engaged position. Grid bars which are in the disengaged position, such as grid bar 8 as illustrated in FIG. 3, will not have their sharp cleaning edge 25 near the teeth of the spinning saws. This means they will neither perform any cleaning function, nor cause a loss of usable lint. The distance between the cleaning edge of a disengaged grid bar to the tip of the teeth of the spinning saws typically ranges from 0.25 to 0.5 inches, or greater. This way the spinning lint held by the teeth of the saw will not be in contact with the sharp cleaning edge of the grid bar and therefore, will not be affected by it. The disengaged grid bar will be set at the rotational angle 31, which is greater than angle 24. As part of this invention, the motors attached to each of the grid bars will manipulate the bar's respective angular position in relation to the saws, positioning them in an engaged position or in a disengaged position. Fine control is used to adjust the distance of the edge from the saws in the engaged position, to finely adjust the amount of trash removed by that bar and to prevent the bars from incidentally touching the saws. The movement of the grid bars is performed at a special slow motion to prevent the flexing or vibration of the bar thus reducing the possibility of the bars touching the saws; an event which may cause sparks and fire in the gin. It should be mentioned that some trash particles 27 will stay with the lint in the process, and miss the cleaning edges of all of the engaged grid bars and will continue to remain with the lint to its final packing stage.

Part of this invention is the design of the grid bar motors and actuators as illustrated in FIGS. 4, 4a and 5. Shown in FIG. 4 is inventive grid bar 7, which is movable via a worm gear assembly. The worm gear assembly contains a toothed wheel 34, a cork screw pin 35, a pivot pin 36, and a shim 37. Stepper motor 38 is connected to the controller via electrical cable 39. The stepper motor is also equipped with an encoder, which enables it to verify the number of revolutions the motor rotates. The invention's motorized grid bar is used to engage and disengage the sharp cleaning edge 25 from the lint in process 16. As the cork screw pin 35 is rotated counter clockwise by the stepper motor 38, it causes the toothed wheel 34 to turn in a clockwise direction. This also rotates the grid bar clockwise since the two are locked together by the shim 37 and turn together on the pin 36. As a result, the grid bar cleaning edge will separate from the saw teeth and from the lint and will no longer take part in active cleaning of the lint 16. This separation will also not cause loss of useable lint. When the stepper motor 38 turns the corkscrew 35 in the clockwise direction the grid bar will return to the engaged cleaning position. The angle of the turn must be accurate so that the grid bar will not come to rest too close to the edge of the saw teeth or come in contact with the saw's teeth. This could cause damage or even a fire. An encoder built into the stepper motor helps determine the number of revolutions the corkscrew makes. From this information the turning angle of the grid bar can be calculated using linear the equation (1). A stop wedge 43 and a stop switch 45 can also help prevent the grid bar from over rotation. As the grid bar rotates to the engaged position, it come to a stop against the stop wedge 43. The wedge stops the rotation of the grid bar by pushing against a step 44 on the edge of the grid bar when it comes to its final resting angle. The step 44 is built into both grid bar edges. The stop wedge 43 is attached to the frame 5 of the machine. The stop switch 45 provides a closed contact signal to the processor via cable 46 when the grid bar

reaches it final engaged position. It can be used by the processor to determine when to stop the rotation of the grid bar.

The angle of rotation ι of the grid bar 7 is calculated in the following equation (1):

(1) $\iota = (w/360) * 360 / N$

where N is the number of teeth on the gear 34, and w is the rotation angle of the step motor 38. The tangent distance of travel for the cleaning edge 25 is R times the angle of rotation in radians, when R is the distance of the cleaning edge from center of rotation.

FIG. 4a shows another alternative actuator for engaging and disengaging the grid bar in and out of the cleaning process. Shown in FIG. 4a is a solenoid 48 with its current driving supply cable 49, and an anchor pin 50 which holds the stationary part of the solenoid fixed to the lint cleaning machinery frame 5, and the plunger 52 which is anchored to the tail of the grid bar 7. There are types of solenoids which operate both forwards and backwards, allowing them to engage or disengage the grid bar by applying the correct electrical signal. Alternatively, a spring 53 can be used to retract the grid bar to its disengaged position. When the solenoid is activated by the application of voltage, it applies pulling force greater then that of the spring, thus bringing the grid bar closer to the saws into the engaged position. When the solenoid is deactivated it releases the grid bar and allows the spring to pull the grid bar away from the saw to the disengaged position. The spring 53 is anchored at one side on the frame 5, and on its other side to a pin on the side of the grid bar 7. The preferred method in which the solenoid 48 is activated, is the application of a pulse width modulated signal. Starting to apply power to the solenoid with a low duty cycle will generate a relatively small force. Gradually, the processor increases the duty cycle to its full one hundred percent for full force application. Gradual application of the solenoid force prevents a sudden movement of the grid bar, thus preventing it from flexing and

incidentally touching the saws 1.

FIG. 5 illustrates another alternative method for engaging and disengaging the grid bars. It utilizes pneumatic or hydraulic cylinders to perform the motion. As illustrated in FIG. 5, a pneumatic cylinder 54 is pinned to the grid bar 7 at its extendable rod 55 using a pin 56. The other end of the cylinder is attached to the frame 5 of the lint cleaner. Two pressurized air or oil carrying pipes 56 and 57 feed into the inside pressure chamber of the cylinder and provide the required force to move the extendable rod 55 in the desired direction. A bar stop structure such as described above may be used with any embodiment of the invention.

FIG. 6 and 6a illustrate the lateral movement of the grid bar along arched and linear positioning grooves according to an aspect of the invention. As part of this invention, the grid bar 7 can be fitted with at least two guiding pins 58 and 59 which extend beyond the sides of the grid bar. These are inserted into guiding grooves 60 which are accomplished in the frame 5 of the lint cleaner. The grooves can be straight or curved. When the grid bar is forced to move to the engaged position, the grooves lead it to that position, stopping it at a desired distance from the teeth of the saws, as the pins reach the end of the grooves. The curved groove 60 can also be designed to position a lint retaining member 61, which is part of the grid bar and extends along the entire length of the grid bar against the teeth of the saw when the grid bar is in the disengaged position. This lint retaining member has a surface that helps to keep the lint in process closely attached to the saws, reducing the possibility of having any lint dislodged and removed during the lint cleaning process by subsequent grid bars' cleaning edges or by the air flow 47 around the saws. Grid bar 7 in FIG. 6 is shown in the disengaged position where the lint retaining member is in close vicinity to the saws. Trash is not removed from the lint in this process and no lint is wasted when removed by the grid bars.

The position of the grid bar in FIG. 6a is in the engaged position, pushed forward to the front end of the grooves.

FIG. 6 shows the grid bar 7 with a lint retaining member 61 of the invention attached. The retaining member is designed to hold the lint being spun by the saw 1, attached to the teeth of the saws. This prevents the lint from being removed from the saws and discarded as trash. The lint retaining member 61 is part of or attached to the bottom side of the grid bar, extending from side to side. It has a smooth, curved surface 63 which prevents the dislodging of lint pieces 28 from the saw 1. The retaining member pushes the lint closer to the teeth of the saws. The retaining member can be an integral part of the grid bar or an attached piece held together with fasteners 62. It can also be inserted into a groove 33 built into the body of the grid bar. The shape of the retaining bar is design to provide maximum retaining member area in proximity to the saw while maintaining safe distance from the teeth of the saws. The material of the retaining bar is non metallic, such that in the event of incidental impact with the saws, the retaining bar will not cause a spark but be chipped off.

FIG. 7 shows details of a brush type of the lint retaining member, attached to the grid bar 7. At least one row of bristles 64 on the brush 65 are attached to the bottom of the grid bar at an angle to its bottom surface. The edge of the brush is positioned close to the rotating saws 1. When the grid bar is in the engaged position the bristles of the brush 64 do not touch the teeth of the saw. When the grid bar is in the disengaged position as shown in FIG. 7, the bristles of the brush do reach the tip of the saws 42 which gently align the lint to the saw's teeth. This keeps the lint flowing over the saws. The brushes on the grid bars are built along the entire length of the grid bar so they reach the entire length of the battery of saws. FIG. 7 also shows the mechanics of a manually operated grid bar. A spring 90 is attached to a pin 91 on the grid bar 7

and to a stationary pin 92 on the body of the lint cleaner 5. The pin 91 is positioned on the side of the grid bar, approximately half way from the tip 25 to the pivot point 93. The stationary pin 92 is attached to the body 5 on the opposite side to the pin 91 in relation to pivot 93 so that when the grid bar is in the engaged position the spring will hold the grid bar 7 against the bottom stop wedge 43, and when the grid bar is in the disengaged position the spring will swing the grid bar away from the saws to that position, as shown in FIG. 7, and hold it steady against the upper stop wedge 95. A handle 96 can be used to swing the grid bars from one position to another manually. The handle will be coupled to the grid bar at its base near or at its pivot point 93, and can be removed when not in used.

FIG. 8 illustrates the variable rate lint cleaning signal flow diagram. The system in this configuration consists of an operator trash set point entry device 66, a grid bar processor 75, an imaging device 70, an image processor 69, and a grid bar driver 76. Also shown in FIG. 8 is the lint before cleaning 16, the lint cleaner saws 1, and a grid bar 11. The operator, using his interface terminal 66, enters a *desired output trash level* Ts, which is fed into the first input port of the grid bar processor 75. This entry represents the desired amount of trash at the end of the cleaning process. The trash level can be presented as a leaf count figure, or other relative number such as a percent of trash. The imaging device 70 captures images of the lint before cleaning 16, and sends them to an image processor 69 for trash level analysis, which is known in the art. The resulting *incoming trash level*, Ti, is fed into the second port of the grid bar processor 75. This figure, the incoming trash level, Ti, can be a leaf count figure or any other relative number such as the percent of trash. The desired output trash level, Ts, and the incoming trash level, Ti, are two input signals used by the grid bar processor 75 to calculate the number of grid bars to be deployed in the lint cleaner. The grid bar processor uses a lookup table such as

Table A to determine the number of grid bars needed to clean the incoming lint to the desired level. If no other imaging devices are installed, this calculation will determine the final number of grid bars to be engaged in the cleaning process. Using Table A one can determine the number of grid bars needed to clean the lint to the desired output trash level. The number of grid bars needed to be engaged are determined by crossing the line of current incoming trash level Ti with the column of the set trash level Ts. The processor activates the grid bars to their engaged or disengaged position starting with grid bar number one, at the top of the lint cleaner such that the grid bars in the engaged position will be consecutive. The outcome of the grid bar processor 75 is fed into the grid bar driver 76 which, in turn, sends the appropriate signals to the grid bars' actuators to move them to the proper engaged or disengaged positions.

Grid bar deployment Table A, or similar, is constructed experimentally in a cotton gin of similar lint cleaner properties as that of the gin where the system and the table is to be utilized. While the gin is operating at a given steady, not varying significantly, input trash level, the operator deploys any number of grid bars combination possible such as one grid bar, two grid bars, three grid bars, etc., at a time, and records the output trash level obtained as the result of each combination. He enters the results into a table of the sort designated as Table A where the columns designated as Desired Output Trash Level (Ts) represent the actual trash level achieved. The operator repeats the procedure for different input trash levels so it covers all the expected range of trash levels expected to be fed into the gin.

Table A; Grid bar deployment schedule

Input Trash Level Ti	Desired Output Trash Level (Ts)								
	1	2	3	4	5	6	7	8	
1	0	0	0	0	0	0	0	0	
2	2	0	0	0	0	0	0	0	
3	4	1	0	0	0	0	0	0	
4	6	3	1	0	0	0	0	0	
5	8	5	3	1	0	0	0	0	
6	10	7	5	3	1	0	0	0	
7	12	9	7	6	3	2	0	0	
8	14	11	9	8	7	6	5	0	

FIG. 9 illustrates the variable rate lint cleaning signal flow diagram with two imaging devices, one at the lint cleaner input before cleaning and one at the lint cleaner output after cleaning. The system in this configuration consists of an operator trash set point entry device 66, a grid bar processor 75, a secondary grid bar processor 77, an input imaging device 70, an output imaging device 73, an input imaging processor 69, an output imaging processor 74, and a grid bar driver 76. The front end portion of this system configuration operates similarly to the one described in FIG. 8. The desired output trash level Ts is fed into a port of the Grid bar processor 75. The incoming trash level signal from the input imaging device 70 is fed to the input image processor 69 and from there is fed into the second port of the grid bar processor 75. The grid bar processor 75 calculates the deployment schedule using Table A and feed the results into the first

port 78 of the secondary grid bar processor 77. The trash set point signal is also fed into the secondary grid bar processor 77 via its port 80. The *output trash level* To, which is obtained from the images taken by the output imaging device 73 and calculated by output imaging processor 74 is also fed into the secondary grid bar processor 77 via its third port 79. The secondary grid bar processor 77 then calculates the final grid bar deployment schedule, using it three input signals and the grid bar deployment correction Table B. The grid bar deployment schedule is sent to the grid bar driver 76 which in turn drives the actuators of the grid bars to the correct engaged or disengaged positions.

In order to reduce the number of alteration the grid bars undertake, the grid bar processors 75 and 77 utilize a rolling averaging formula (2) which outputs the results once every user selectable output deployment time interval.

(2) $$GB(Drive) = int\,(a0{*}GB(t) + a1{*}GB(t-1) + \ldots + ai{*}GB(t-2) + \ldots\ an{*}GB(t-n) + a)$$

Where:

GB(Drive) is the averaged grid bar deployment figure to be output to grid bar driver,

GB(t) is the grid bar deployment figure from the current calculation cycle,

GB(t-1) is the grid bar deployment figure from the previous calculation cycle,

...

GB(t-n) is the grid bar deployment figure from the *n*th previous calculation cycle

a0 through *an* are coefficients of weight which can be adjusted to increase or decrease the affect of the averaging. *a0* through *an* are smaller then 1 and greater or equal to 0 except of a0 which should always be greater then 0. The sum of the coefficients *a0* through *an* should be equal to 1. *a* is a constant used to round up to the nearest integer; $0 < a < 1$.

The number and coefficients *ai* can be chosen to be any number greater then 1. at least

a0 should be greater than 0. The number and the value is determined based on the stability and responsiveness of the system during operation. When the final grid bar deployment figure GB(Drive) is varying too often then the system shall include more coefficients, averaging the calculation over longer sequence of grid bar deployment figures. When greater responsiveness is required due to fast changing conditions of the lint, a smaller number of coefficients should be used, but more than 0, so the average will be of shorter history.

Grid bar deployment Table B is constructed experimentally in a cotton gin of similar lint cleaner properties as that of the gin where the system and the table is to be utilized. While the gin is operating at a given steady, not varying significantly, input trash level, the operator records the *trash removal error* defined as Ts-To and then he engages or disengages one or more grid bars to bring this error to zero or close to it within half of a point. The proper correction is then recorded in the corresponding column on the same line. It should be noted that at different input trash levels there may be different corrections to grid bar schedule thus requiring the creation of multiple tables of type B, one for each level of input trash level.

Table B; Grid bar deployment correction schedule.

Difference between set point and out trash (Ts – To)	Correction to number of grid bars to be engaged (positive number = bars to engage Negative number = bars to disengage)
-1.5	2
-1.0	1
-0.5	1
0	0
0.5	-1
1.0	-1
1.5	-2

Since most gins require two or more lint cleaners in order to clean the lint to the commonly specified level, the system described in this invention can utilize three way flow valves to route the lint through multiple cleaners, or bypass any one or more of them, in any desired order. Illustrated in FIG. 10, with a use of a valve 81, the gin operator can operate only one lint cleaner 88 with motorized grid bars 11, yet have complete flexibility as to the number of grid bars he engages. Using one or more lint valves 81, any number of grid bars from one to m * n can be engaged in the cleaning process. Where n is the inherent number of grid bars contained in a single lint cleaner of the type being used in the facility, and m is the number of lint cleaners used in the facility. FIG. 10 shows two lint cleaners, standard lint cleaner 86 with four stationary grid bars 87, and the inventive lint cleaner 88 with four motorized grid bars 11 (only one shown). The lint cleaners are connected via a three-way valve 81. The three-way valve has a motorized

gate 82 which can direct the lint from its input 83 port to either the primary output port 84 or the secondary output port 85. Thus when fewer then four grid bars are needed to clean the lint to the desired level of cleanliness, the ginner can flip the gate 82 down so the lint will bypass the second lint cleaner 86, thus unnecessary loss of lint is eliminated.

As part of this invention, the trash image processors 69 and 72 calculate the amount of trash present in the lint. The image must be clipped so it does not include area which is not fully covered by the lint. This can be determined by calculating the amount of dark areas in different areas of the image. Portions which contain dark spots in excess of 5% are suspected of being poorly covered by the lint and should be excluded from the trash estimation process. The images are converted to a black and white image with the threshold set to 50 percent. This threshold level can be adjusted permanently or dynamically for lighting variation present during the taking of the images.

Table A provides the deployment schedule for grid bars. For every input trash level, also known as input leaf count, and for every output trash level, or leaf count, the operator can determine the number of grid bars to be deployed by reading the cell in the Table A which crosses the line and column of the corresponding trash figures. The table itself can be generated empirically by cleaning lint of different level of trash contents with the different grid bar deployment, starting with one bar through the entire set of grid bars in the cleaner, and measuring the effect in every case.

Table B provides the deployment correction for the lint cleaner's grid bars when an output imaging sensor is available to measure the output trash contents. The table can be used in the manual mode when the output leaf count figure is obtained from a qualified inspector. The table can be used in automatic mode where the output leaf count is fed to the grid bar processor

77 shown in FIG. 9.

In the manual mode the operator can enter the output trash contents, into the operator terminal 66. The data is then transmitted to the grid bar processor 77 where the final grid bar deployment correction is determined based on Table B.

In the automatic mode the output trash content is calculated by the output image processor 74 and the result is transmitted to the secondary grid bar processor 77. The processor uses Table B to determine the correction to the grid bars deployment based on the output trash level To and the desired trash level set by the operator as a input set point Ts. The processor calculates the difference Ts-To and determines the correction schedule according to the number appearing in the right column of the Table B. A positive number designates an increase in the number of grid bars to be engaged, and a negative number designates a decrease in the number of grid bars to be deployed. The result is sent to the grid bar driver as the final deployment. It should be mentioned that this correction determination based on Table B should be performed after the initial deployment determined by Table A and the input trash level content as executed by the first grid bar processor 75 of FIG. 9.

What is claimed is:

References

[1] Anthony; US Patent 5,909,786 Apparatus and method for reducing fiber waste.

[2] Mayfield et al.; Effects of Grid Bars On Lint Cleaners Performance; The Cotton Gin and Oil Mill Press; June 13, 1992.